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Changes in proportions of empty body depots and constituents for nine breeds of cattle under various feed availabilities

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Changes in Proportions of Empty Body Depots and Constituents for Nine Breeds of Cattle Under Various Feed Availabilities

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ABSTRACT: Mature cows (146) representing Angus, Braunvieh, Charolais, Gelbvieh, Hereford, Limousin , Pinzgauer, Red Poll, and Simmental breeds were slaughtered to contribute to the investigation of the effect of various feed availabilities on body composition. Weights recorded when cows were placed on feed were used to set daily diets at four rates of intake within each breed (55, 76, 96, and 111 g DM/[kg $wt^{.75}\cdot$d]). Cows remained on their assigned daily feed allotment throughout the study (3 to 5 yr). On the day of slaughter, shrunk live weights were recorded. Chemical determinations of protein (nitrogen $\times$ 6.25), ether extractable lipid, ash of dry matter, and moisture for hide and offal were obtained for all cows. Chemical determinations of these same constituents were obtained for the carcass soft tissue of 98 cows. Relationships among estimator traits carcass ash, warm carcass weight, resistive impedance, and carcass water from the 97 carcasses were used to predict the carcass constituents for the remaining 49 cows. Within breed, relationships between proportions of fat and empty body (sum of fat, ash, water, and protein from the three body pools of hide, offal, and carcass) were used to estimate empty body weight at 251 g fat/kg (standard reference body weight) for each of the nine breeds. Proportions of offal, carcass, hide, chemical constituents, and selected abdominal and thoracic organs relative to empty body weight from cows that attained weight stasis were regressed on one minus the ratio of individual actual empty body weight to breed standard reference weight. Among mature cows attaining weight stasis at various feeding rates, the proportion of offal remained constant, proportions of fat in carcass, hide, and offal increased with increasing feed level, and proportions of water and protein decreased. Significant variation (P < .01) attributable to breed in proportions of carcass, offal, hide, chemical constituents of the hide and offal, water, and protein of the carcass and selected organs was observed.

Key Words: Body Composition, Cows, Maturity, Reference Weight

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Introduction

Taylor (1980) recommended that comparisons among breeds be made after scaling for mature size. Brown et al. (1972), Smith et al. (1976) and Jenkins et al. (1991) estimated mature weights of several breeds or breed crosses of beef cattle. An implicit assumption is that the estimate of mature weight was at a constant body composition. Empty body composition of mature cows has been shown to vary with the nutritional environment (Ferrell and Jenkins, 1984; Wright and Russell, 1984; Houghton et al., 1990) interacting with the genetic potential for lactation (Jenkins et al., 1986). McClelland et al. (1976) reported no differences among five breeds of sheep in proportions of muscle, fat, or bone when compared at the same degree of maturity. Oberbauer et al. (1994) found no differences in proportions of empty body chemical constituents of Dorset and Suffolk rams when the breeds were compared at the same degree of maturity. Taylor and Murray (1991) defined standard mature weight among mature cows representing dairy, dual purpose, and beef cattle breeds as the live weight at which the mature animal would have total body lipid of .25 kg fat/kg empty body. These authors reported genetic differences in proportions of body tissues and organs when evaluated at standard mature weight. These differences were attributed to differences in milk potential per unit of body weight among the breeds.

The objective of the present study was to investigate the changes in the composition of the empty body of mature cows chronically fed at various feed rates to attain weight stasis. This included estimating standard mature empty body weights for diverse breeds of cattle, estimating proportions for specific organs, empty body depots, and chemical constituents

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of the depots, and detecting if differences exist among diverse breeds of cattle for proportions of empty body components relative to standard mature empty body weight when evaluated after achieving weight stasis.

Materials and Methods

Animals. Mature nonpregnant nonlactating cows from Angus, Braunvieh, Charolais, Gelbvieh, Hereford, Limousin, Pinzgauer, Red Poll, and Simmental breeds were sampled from a life cycle efficiency project (Jenkins and Ferrell, 1994). At the initiation of the life cycle efficiency study, representative cows of each breed were randomly assigned to one of four rates of dry matter intake (DMI): 58, 76, 93, or 111 g/wt$^{.75}$. Daily diet intakes were calculated using these rates and weights of the cows at the time of assignment to the life cycle evaluation. During the third year of the initial project, plans were revised to allow cows completing the life cycle efficiency study to remain on feed until weight stasis was attained. To achieve this, following weaning of the last calf, which ended the life cycle evaluation, cows continued to receive their assigned daily intakes until weight stasis was attained (no weight change for 8 wk). A total of 131 cows representing Angus (14), Braunvieh (13), Charolais (14), Gelbvieh (16), Hereford (13), Limousin (16), Pinzgauer (14), Red Poll (16), and Simmental (15) previously assigned to the life cycle production efficiency project were included in the weight stasis evaluation. Cow weights were recorded weekly. Weight stasis was attained when the coefficient resulting from the regression of weekly weights on the dates of measurement did not differ from zero for any 8-wk period. As cows attained weight stasis (110), they were slaughtered within 5 d. Shrunk live weights and condition scores (9-point scale, 1 = extremely thin, 9 = extremely fat) were recorded on the day of slaughter. Of the cows attaining weight stasis, records of four cows were deleted for specific traits where measurements were missing.

Measurements recorded on day of slaughter were weights for warm carcass, hide, fore and hind hooves, and digesta-free viscera. Digesta-free viscera is the empty gastrointestinal tract plus visceral organs and intra-abdominal fat. Measurements of resistive impedance were recorded (Jenkins et al., 1995). Approximately 48 h after death, one side of each carcass was fabricated into totally trimmed lean product, fat trim, and bone trim with weights for each recorded. As part of the original design of the life cycle efficiency project, a provision for sampling the breeds for determination of empty body composition was included (two per breed-feeding rate subcell). The protocol allowed sampling to occur as cows were removed for injury, chronic or acute diseases during the study or at the end of the project. Fifteen cows were sampled in this manner. Information from these animals and the 131 cows in the efficiency study was included in the determination of empty body standard reference weight.

Composition Data. For all cows, hide and all other noncarcass tissues pooled (digesta-free viscera, head, fore and hind hooves, and visceral organs) were ground separately, with 100- to 125-g samples of each obtained for subsequent analysis of dry matter, lipid, ash, and nitrogen content. Carcass trimmed lean tissue for 97 cows was ground with 100- to 125-g samples taken. Subsequently, the samples from the three depots, hide, offal, and carcass trimmed lean, were analyzed for dry matter (water content by difference between dry and wet sample weight), ether extractable lipid, ash, and nitrogen (protein by nitrogen $\times$ 6.25) following procedures outlined by Ferrell and Jenkins (1984). These constituents were calculated for bone tissue by assuming bone contained 35.8% water, 44.5% fat-free dry matter, and 19.7% fat (C. L. Ferrell, unpublished data). Fat trim was assumed to be 82% dry matter, and 72% of the remaining dry matter was assumed to be ether-extractable lipids. Hide and noncarcass tissue measurements were analyzed for 146 cows, and carcass dissectable lean tissue was analyzed for 97 cows. Within-breed regression equations were developed to predict chemical constituents for the 49 cows whose carcasses were not fabricated. Within-breed regressions including warm carcass weight and resistive impedance as estimative traits were used to predict carcass ash. Pooled multiple regression equations involving warm carcass weight and resistive impedance estimators were used to predict water content. Carcass protein was predicted with a pooled regression equation containing carcass water as the predictor variable. Carcass fat was calculated as the difference between warm carcass weight and the sum of predicted water, ash, and protein. Any errors of prediction will be contained in carcass fat. Empty body weight (blood free) was the sum of the weights for the warm carcass, digesta free viscera plus head, fore and hind hooves, and hide.

Traits Analyzed. Empty body depots, warm carcass weight, digesta-free viscera mass plus head, fore and hind hooves, and hide were expressed as proportions of empty body weight for individual observations. Proportions of chemical constituents within each depot relative to empty body weight were determined. Variables of interest included proportion of specific visceral organs relative to empty body weight, i.e., heart, lung, reticulo-rumen complex, liver, kidney, and small intestine. Breed estimates for weights of empty body at 251 fat/empty body (g/kg) were derived by within-breed regressions of proportion of total empty body fat relative to empty body weight on empty body weight. Using the constants and coefficients from these regressions, standard reference empty body weights were calculated for each breed.

Taylor and Murray (1991) suggested differences among mature animals attaining weight stasis through varying feeding rate may be explored by regressing the observed component proportions on deviation of the proportion of the animal's empty body weight at weight stasis relative to a standard mature weight (A), from one (A/A). Standard mature weight (A) here is defined within breed, to contain 251 g/kg of fat relative to empty body weight. These authors defined the constant from these regressions as mean values for normal adult body composition.

Statistical Analysis. Least squares procedures (SAS, 1985) were implemented to evaluate the effect of breed and feeding rates on untransformed proportion empty body depots and chemical constituents. These untransformed values were regressed on proportion of empty body weight scaled to the breed mean standard reference weight using analyses of covariance (Steele and Torrie, 1960). Least squares procedures were used to partition the sources of variation of breed as a fixed effect and the deviation of the observed proportion of empty body weight relative to breed standard reference empty body weight as the covariate (Harvey, 1987). Pooled regressions were used when slopes were found homogeneous, and *t*-tests were used to determine whether individual breed deviations differed from 0 when the covariate value was 0.

Results and Discussion

Characterization of Test Animals and Traits of Interest. Age at slaughter of the test animals was approximately 10 (SD 1.4) yr. Descriptive statistics

Table 1. Live animal traits by breed and dry matter intake level[a]

Intake level/breed	n	Live weight, kg		Condition score		DM intake, kg	Height, cm
		Initial	Final	Initial	Final		
58 g DM/kg wt$^{.75}$							
Angus	4	559 (27)	500 (35)	5.2 (.5)	5.0 (1.1)	7.5 (.3)	127 (4.5)
Braunvieh	2	554 (74)	488 (82)	3.8 (0)	3.6 (.2)	8.1 (.9)	130 (.2)
Charolais	3	605 (97)	570 (68)	4.7 (.6)	4.3 (.6)	8.8 (1.0)	140 (6.4)
Gelbvieh	5	614 (80)	565 (76)	4.3 (.4)	4.7 (1.4)	7.9 (.7)	138 (3.8)
Hereford	4	589 (41)	568 (61)	6.3 (1.1)	5.4 (.9)	7.5 (.8)	131 (3.6)
Limousin	4	565 (48)	482 (77)	4.4 (.5)	4.0 (.4)	7.2 (.3)	135 (4.4)
Pinzgauer	5	599 (107)	540 (100)	4.2 (1.0)	4.4 (1.2)	7.7 (.6)	139 (6.7)
Red Poll	3	509 (35)	388 (21)	4.8 (0)	3.3 (.4)	7.3 (.6)	128 (4.3)
Simmental	4	613 (56)	538 (75)	4.3 (.2)	3.9 (1.0)	7.1 (.8)	138 (5.1)
76 g DM/kg wt$^{.75}$							
Angus	2	517 (13)	588 (17)	5.3 (0)	7.0 (.3)	7.9 (.6)	127 (.9)
Braunvieh	4	584 (58)	567 (35)	4.6 (.5)	5.5 (.5)	10.7 (1.3)	133 (2.1)
Charolais	5	687 (63)	707 (46)	5.3 (1.1)	5.2 (1.0)	10.7 (1.2)	143 (5.0)
Gelbvieh	3	569 (68)	590 (101)	4.3 (1.1)	5.2 (1.2)	9.0 (.9)	137 (3.3)
Hereford	4	577 (7)	574 (63)	5.6 (.5)	5.6 (1.7)	9.2 (1.5)	131 (3.3)
Limousin	6	619 (76)	583 (46)	5.9 (1.5)	4.2 (2.4)	9.9 (.8)	135 (1.2)
Pinzgauer	3	501 (29)	576 (57)	3.8 (.4)	5.4 (1.2)	8.4 (.5)	131 (3.2)
Red Poll	4	439 (47)	468 (43)	3.5 (.4)	4.8 (.5)	8.7 (1.4)	127 (2.9)
Simmental	4	589 (48)	600 (75)	4.2 (.6)	5.1 (.7)	9.9 (.7)	137 (2.4)
93 g DM/kg wt$^{.75}$							
Angus	3	607 (13)	613 (54)	6.7 (.7)	6.8 (.7)	11.3 (1.4)	130 (.8)
Braunvieh	3	626 (52)	724 (60)	5.4 (1.0)	6.9 (.7)	12.3 (1.0)	140 (.7)
Charolais	5	677 (67)	751 (81)	5.8 (1.2)	7.3 (.5)	12.0 (.9)	143 (3.7)
Gelbvieh	3	566 (33)	634 (96)	4.5 (.5)	5.7 (1.0)	11.8 (1.3)	135 (2.3)
Hereford	4	552 (82)	623 (76)	5.8 (1.2)	7.3 (.9)	10.7 (1.4)	129 (7.2)
Limousin	6	622 (74)	650 (36)	5.7 (1.4)	6.2 (.8)	11.1 (1.3)	136 (3.5)
Pinzgauer	3	547 (39)	673 (88)	4.5 (–)	6.9 (1.0)	11.0 (1.0)	133 (2.6)
Red Poll	5	448 (56)	542 (40)	4.2 (.6)	5.9 (1.0)	10.1 (1.1)	126 (3.1)
Simmental	5	658 (125)	748 (81)	4.7 (1.2)	6.9 (1.1)	12.7 (1.5)	147 (1.5)
111 g DM/kg wt$^{.75}$							
Angus	5	550 (98)	619 (41)	5.9 (1.1)	7.5 (.6)	11.4 (2.4)	130 (1.6)
Braunvieh	4	607 (94)	676 (119)	5.2 (2.3)	6.2 (1.8)	13.1 (1.4)	134 (2.0)
Charolais	3	700 (44)	737 (35)	5.1 (.2)	6.2 (.1)	14.1 (1.0)	142 (1.5)
Gelbvieh	5	607 (107)	705 (71)	5.0 (1.7)	6.8 (1.1)	12.7 (1.5)	137 (2.6)
Hereford	4	550 (46)	634 (40)	5.4 (.9)	7.7 (.3)	10.8 (1.1)	128 (4.5)
Limousin	6	577 (58)	636 (68)	5.2 (1.4)	6.5 (.4)	11.0 (1.4)	137 (2.0)
Pinzgauer	3	532 (69)	682 (46)	4.1 (.9)	6.7 (.3)	12.4 (1.7)	133 (5.8)
Red Poll	5	491 (122)	600 (73)	4.8 (1.8)	6.6 (.6)	12.5 (2.6)	127 (3.0)
Simmental	5	587 (82)	689 (54)	4.1 (1.2)	6.0 (1.3)	12.5 (.9)	141 (4.9)

[a]Values are means, with SD in parentheses.

(means and standard deviations) for initial and final weight, initial and final subjective condition scores (9-point system), daily dry matter intake, and height at the hips are presented by breed and feeding rates in Table 1. Initial weight reflects the weight of the cows at the time they were assigned to the life cycle efficiency study. For cows assigned to the life cycle efficiency study, initial weight is the weight of the cow recorded shortly after weaning a calf under pasture conditions. Cows identified as possible replacements at the initiation of the life cycle efficiency study received a daily intake calculated using the 76 g or 93 g of DM/on test wt$^{.75}$ feeding rate. For cows entering the life cycle efficiency study as replacements (39), initial weight represents the weight of the animal after receiving this intake rate from time of assignment as a replacement until assignment to the study. The trait final live weight is the weight at time of slaughter. Traits and initial and final condition scores were recorded at these times. Height represents the mean of multiple height measurements taken at the hip for individual cows averaged within breed and feeding rate. Dry matter intake represents the mean daily intake of diets for the breed-feeding rate subcells throughout the life cycle efficiency and weight stasis studies. Cows originally assigned to the life cycle study contributed DM intake data for approximately 6 yr. Cows removed and killed or that entered the life cycle as replacements contributed information during their tenure, which varied from 2 to 4 yr. Mean initial weight for all cows was 581 kg, final weight was 611 kg, beginning and ending condition scores were 4.9

Table 2. Specific thoracic and abdominal organ weights (kg) by breed and dry matter intake level[a]

Intake level/breed	n	Heart	Lung	Liver	Kidney	Rumen complex	Small intestine
58 g DM/kg wt$^{.75}$							
Angus	4	2.15 (.35)	2.86 (.30)	4.84 (.50)	1.30 (.26)	15.9 (1.8)	5.0 (.6)
Braunvieh	2	2.46 (.11)	3.08 (.10)	5.12 (.32)	1.30 (.01)	14.2 (.6)	5.6 (1.1)
Charolais	3	2.37 (.15)	2.94 (.59)	5.24 (.74)	1.32 (.08)	17.2 (2.5)	5.0 (1.1)
Gelbvieh	5	2.48 (.26)	2.90 (.63)	5.41 (.80)	1.20 (.18)	17.1 (1.8)	5.4 (1.2)
Hereford	4	2.39 (.17)	2.86 (.47)	5.17 (.58)	1.34 (.11)	16.0 (3.2)	6.0 (.6)
Limousin	4	2.14 (.25)	2.89 (.35)	4.42 (.47)	1.62 (.81)	14.8 (1.3)	4.8 (.8)
Pinzgauer	5	2.45 (.63)	3.15 (.42)	5.49 (1.56)	1.24 (.22)	15.2 (2.4)	5.3 (.8)
Red Poll	3	2.04 (.11)	3.41 (.71)	4.61 (.27)	1.33 (.35)	14.4 (2.2)	4.9 (.3)
Simmental	4	2.47 (.18)	3.23 (.28)	4.56 (.57)	1.16 (.15)	16.4 (3.4)	5.1 (.7)
76 g DM/kg wt$^{.75}$							
Angus	2	2.47 (.67)	2.94 (.02)	5.25 (.53)	1.19 (.11)	16.7 (4.0)	4.5 (.4)
Braunvieh	4	2.58 (.07)	3.14 (.44)	5.67 (.26)	1.33 (.14)	17.5 (1.0)	6.7 (.6)
Charolais	5	2.89 (.11)	3.48 (.38)	6.78 (.47)	1.55 (.07)	18.7 (1.4)	6.9 (.8)
Gelbvieh	3	2.58 (.40)	3.57 (.95)	5.81 (.82)	1.38 (.24)	14.6 (3.2)	5.7 (1.0)
Hereford	4	2.42 (.13)	2.83 (.35)	5.14 (.42)	1.22 (.10)	14.9 (.9)	6.1 (.5)
Limousin	6	2.41 (.39)	2.57 (.41)	5.35 (.40)	1.29 (.08)	15.2 (1.7)	5.9 (.5)
Pinzgauer	3	2.59 (.35)	2.70 (.17)	5.88 (.52)	1.28 (.12)	17.3 (4.3)	6.3 (1.3)
Red Poll	4	2.12 (.30)	2.78 (.52)	5.11 (.34)	1.10 (.08)	14.0 (.9)	5.4 (.9)
Simmental	4	2.66 (.45)	2.94 (.42)	6.27 (.57)	1.35 (.09)	18.1 (1.8)	7.1 (2.3)
93 g DM/kg wt$^{.75}$							
Angus	3	2.94 (.48)	2.93 (.49)	6.71 (1.03)	1.34 (.12)	16.9 (2.3)	6.1 (.4)
Braunvieh	3	3.09 (.11)	3.46 (.58)	7.02 (.33)	1.72 (.09)	17.5 (.9)	7.3 (.7)
Charolais	5	3.08 (.35)	3.15 (.42)	7.23 (.51)	1.66 (.15)	16.7 (1.7)	7.1 (.7)
Gelbvieh	3	2.96 (.37)	4.25 (1.68)	6.21 (1.30)	1.52 (.30)	14.4 (2.9)	5.8 (1.5)
Hereford	4	2.64 (.33)	3.24 (.63)	5.72 (.32)	1.46 (.30)	17.0 (2.9)	6.6 (.7)
Limousin	6	2.54 (.40)	2.73 (.40)	5.72 (.53)	1.41 (.13)	16.4 (2.2)	6.0 (.6)
Pinzgauer	3	2.77 (.81)	3.20 (.46)	6.28 (1.64)	1.50 (.10)	17.2 (2.3)	6.8 (.9)
Red Poll	5	2.24 (.22)	2.66 (.21)	6.01 (.56)	1.41 (.15)	14.9 (.6)	5.9 (.6)
Simmental	5	3.51 (.57)	3.40 (.16)	7.09 (.57)	1.57 (.13)	19.2 (2.1)	7.4 (.4)
111 g DM/kg wt$^{.75}$							
Angus	5	2.55 (.09)	2.74 (.55)	6.30 (.65)	1.29 (.21)	14.9 (1.9)	6.1 (.3)
Braunvieh	4	3.28 (.31)	3.35 (.12)	7.55 (.77)	1.51 (.22)	17.1 (1.1)	8.0 (2.0)
Charolais	3	3.02 (.42)	3.52 (.54)	6.68 (.49)	1.58 (.15)	19.6 (2.9)	6.1 (.3)
Gelbvieh	5	2.90 (.23)	3.48 (.62)	7.19 (.68)	1.49 (.15)	16.6 (1.8)	6.2 (.8)
Hereford	4	2.98 (.37)	3.04 (.27)	5.81 (.62)	1.48 (.15)	15.7 (.8)	6.8 (.4)
Limousin	6	2.68 (.30)	2.84 (.17)	5.69 (.61)	1.40 (.09)	16.0 (1.6)	6.0 (1.2)
Pinzgauer	3	2.50 (.48)	3.33 (1.09)	6.94 (.67)	1.53 (.31)	15.9 (4.1)	6.4 (.4)
Red Poll	5	2.45 (.42)	2.75 (.14)	5.84 (.71)	1.38 (.14)	15.5 (2.3)	5.9 (.4)
Simmental	5	3.11 (.42)	3.58 (1.01)	6.58 (1.16)	1.43 (.22)	18.3 (1.7)	7.1 (.8)

[a]Values are means, with SD in parentheses.

Table 3. Constituents (kg) of hide, offal, and carcass by breed and dry matter intake level[a]

Intake level/breed	n	Water Hide	Water Offal	Water Carcass	Protein Hide	Protein Offal	Protein Carcass	Fat Hide	Fat Offal	Fat Carcass	Ash Hide	Ash Offal	Ash Carcass
58 g DM/kg wt$^{.75}$													
Angus	4	22.6 (3.9)	49.9 (5.8)	165 (10)	8.9 (3.0)	15.5 (2.1)	39.2 (3.0)	2.6 (.45)	21.8 (7.2)	56.8 (9.4)	.33 (.17)	5.0 (.1)	18.0 (.9)
Braunvieh	2	22.7 (1.7)	54.6 (2.4)	175 (25)	12.6 (.1)	14.7 (.6)	41.3 (6.9)	1.4 (1.94)	15.5 (13.8)	34.7 (30.3)	.36 (.13)	4.5 (.9)	20.5 (.9)
Charolais	3	25.6 (2.0)	52.7 (6.9)	209 (24)	13.8 (.6)	15.0 (2.0)	51.9 (7.4)	1.0 (.53)	19.2 (7.2)	43.6 (22.2)	.37 (.06)	5.9 (.4)	23.3 (2.1)
Gelbvieh	5	28.1 (2.8)	58.0 (5.9)	214 (32)	14.9 (2.1)	15.4 (1.7)	52.0 (8.6)	1.1 (.76)	18.8 (6.9)	38.3 (18.2)	.39 (.10)	4.8 (1.1)	21.8 (1.3)
Hereford	4	26.5 (1.2)	55.9 (8.1)	193 (20)	14.1 (1.4)	15.7 (1.6)	47.0 (4.0)	2.6 (1.12)	24.4 (6.7)	71.9 (25.0)	.33 (.07)	5.3 (1.0)	20.3 (1.6)
Limousin	4	21.5 (2.9)	50.8 (4.5)	190 (31)	10.9 (.5)	14.2 (1.0)	44.8 (7.9)	.6 (.32)	12.4 (6.8)	27.9 (17.7)	.30 (.05)	4.8 (1.1)	19.0 (1.7)
Pinzgauer	5	28.7 (2.6)	53.8 (6.2)	191 (32)	15.9 (2.9)	14.9 (2.2)	46.6 (8.7)	1.5 (1.02)	21.6 (11.0)	56.3 (34.2)	.40 (.06)	4.9 (1.1)	21.4 (1.2)
Red Poll	3	18.0 (2.1)	48.4 (6.8)	139 (12)	8.8 (1.0)	12.8 (.8)	31.6 (3.1)	.53 (.53)	10.2 (4.8)	17.4 (10.5)	.26 (.02)	4.2 (.3)	16.8 (1.4)
Simmental	4	25.8 (3.3)	55.5 (4.9)	202 (17)	14.0 (2.0)	14.0 (1.1)	47.4 (4.5)	.9 (.76)	14.4 (10.1)	28.9 (19.3)	.55 (.30)	4.8 (.8)	21.7 (1.8)
76 g DM/kg wt$^{.75}$													
Angus	2	21.1 (.31)	51.4 (7.0)	148 (51)	10.7 (.8)	14.2 (.7)	46.7 (2.1)	3.2 (.02)	37.3 (1.1)	123.9 (.4)	.38 (.19)	4.7 (.1)	17.3 (.7)
Braunvieh	4	25.1 (2.34)	57.1 (2.3)	193 (10)	13.4 (1.1)	16.2 (.6)	48.7 (3.7)	1.5 (.49)	25.1 (6.5)	59.6 (25.0)	.38 (.12)	5.1 (.8)	20.2 (.7)
Charolais	5	27.6 (1.55)	64.1 (3.2)	268 (31)	15.3 (1.9)	18.4 (1.8)	68.9 (7.9)	2.4 (.55)	31.9 (6.1)	66.1 (20.9)	1.00 (.81)	6.3 (1.1)	27.3 (2.8)
Gelbvieh	3	25.3 (1.56)	56.5 (11.0)	207 (29)	12.5 (.7)	16.2 (.7)	54.5 (8.1)	2.7 (1.59)	30.8 (15.1)	67.4 (29.7)	.54 (.08)	5.3 (1.4)	20.6 (1.4)
Hereford	4	25.4 (1.3)	54.7 (2.7)	195 (11)	13.8 (1.4)	16.9 (.6)	51.0 (3.3)	3.3 (.93)	28.1 (8.8)	86.8 (33.9)	.52 (.10)	5.7 (1.2)	20.6 (1.6)
Limousin	6	21.9 (1.3)	53.0 (4.9)	231 (42)	12.6 (1.3)	15.9 (1.3)	57.7 (6.9)	1.3 (.51)	32.9 (13.4)	61.7 (20.6)	.38 (.10)	6.4 (1.1)	20.0 (1.3)
Pinzgauer	3	26.6 (2.2)	54.1 (2.1)	190 (4)	13.9 (1.1)	15.5 (.1)	49.2 (3.4)	2.9 (1.6)	36.7 (18.2)	70.9 (38.4)	.43 (.09)	6.3 (.2)	20.7 (.7)
Red Poll	4	20.8 (2.7)	47.4 (2.7)	165 (12)	10.4 (.9)	13.4 (.7)	41.2 (5.0)	1.9 (.49)	21.8 (3.9)	49.8 (14.3)	.30 (.03)	4.4 (.2)	17.9 (.4)
Simmental	4	27.5 (3.1)	59.5 (3.7)	211 (18)	14.1 (1.8)	16.9 (2.2)	55.7 (5.1)	1.8 (1.36)	25.4 (7.6)	54.8 (31.0)	.51 (.14)	5.3 (1.2)	21.8 (1.2)
93 g DM/kg wt$^{.75}$													
Angus	3	20.6 (2.5)	57.9 (7.4)	204 (21)	11.2 (1.9)	16.5 (.9)	54.3 (6.9)	3.3 (.4)	39.4 (17.5)	113.8 (41.9)	.36 (.05)	5.1 (1.3)	19.8 (.4)
Braunvieh	3	28.0 (.9)	68.2 (7.0)	230 (24)	15.2 (1.0)	19.7 (.6)	61.7 (6.9)	2.8 (.3)	45.9 (13.9)	122.5 (14.8)	.42 (.01)	6.5 (.4)	23.4 (2.0)
Charolais	5	26.7 (4.9)	62.6 (5.0)	256 (16)	14.7 (2.6)	19.2 (2.4)	69.0 (4.0)	3.7 (1.5)	54.5 (9.7)	142.2 (28.0)	.60 (.17)	6.3 (1.7)	24.4 (3.1)
Gelbvieh	3	28.4 (3.6)	65.2 (8.7)	216 (28)	14.6 (2.4)	19.6 (3.3)	57.0 (7.9)	2.5 (1.4)	27.7 (5.7)	67.9 (35.8)	.53 (.10)	6.6 (2.8)	22.5 (1.7)
Hereford	4	25.7 (2.6)	60.6 (7.4)	206 (28)	13.3 (.8)	17.4 (2.3)	54.0 (8.7)	4.2 (1.2)	37.9 (7.6)	98.3 (39.4)	.39 (.09)	5.7 (1.7)	21.6 (4.0)
Limousin	6	23.9 (1.3)	56.0 (4.9)	239 (17)	12.6 (.9)	17.0 (1.3)	62.7 (3.9)	2.5 (.7)	38.6 (9.7)	90.0 (14.5)	.45 (.22)	5.7 (1.1)	21.4 (1.6)
Pinzgauer	3	28.3 (5.4)	60.1 (8.7)	209 (31)	15.4 (4.6)	17.4 (3.4)	55.3 (7.4)	3.8 (2.3)	57.1 (14.3)	123.9 (25.0)	.35 (.17)	5.4 (1.3)	20.4 (2.2)
Red Poll	5	18.7 (1.6)	55.6 (9.0)	171 (17)	10.5 (1.4)	16.3 (3.2)	46.0 (4.4)	2.6 (1.0)	49.7 (11.1)	81.0 (14.2)	.36 (.07)	5.0 (1.0)	17.2 (1.3)
Simmental	5	30.2 (4.5)	70.0 (3.2)	249 (14)	16.2 (2.6)	20.1 (.8)	66.4 (4.8)	3.1 (.7)	43.2 (11.4)	126.1 (44.1)	.46 (.14)	5.3 (1.0)	24.5 (.9)
111 g DM/kg wt$^{.75}$													
Angus	5	23.1 (3.1)	52.6 (3.6)	196 (21)	11.9 (1.6)	15.5 (1.5)	53.4 (5.4)	5.3 (1.7)	48.2 (8.6)	133.8 (24.0)	.93 (1.22)	4.7 (.9)	19.7 (1.8)
Braunvieh	4	27.4 (2.6)	67.7 (5.7)	220 (22)	14.4 (1.0)	18.3 (1.9)	58.6 (7.3)	3.9 (3.1)	47.5 (26.0)	99.3 (52.3)	.56 (.23)	5.2 (.8)	22.4 (2.0)
Charolais	3	25.9 (2.4)	64.6 (4.0)	275 (10)	14.3 (.2)	19.5 (1.5)	70.6 (4.3)	2.3 (1.0)	38.4 (19.4)	86.2 (39.6)	.39 (.04)	6.5 (.8)	27.0 (1.9)
Gelbvieh	5	27.6 (1.4)	62.9 (4.2)	252 (34)	14.7 (1.0)	18.1 (1.8)	67.6 (9.8)	3.2 (.5)	37.6 (7.3)	100.1 (21.1)	.52 (.11)	5.5 (1.2)	24.9 (1.9)
Hereford	4	25.8 (2.5)	54.7 (3.0)	209 (17)	13.6 (1.7)	16.8 (1.1)	54.6 (5.6)	5.3 (1.0)	39.9 (8.0)	120.6 (11.5)	.51 (.13)	5.8 (.5)	22.1 (.9)
Limousin	6	22.5 (3.1)	56.3 (3.1)	241 (13)	12.6 (2.0)	17.0 (2.0)	64.0 (6.1)	1.7 (.6)	32.5 (16.1)	81.0 (36.6)	.39 (.11)	5.8 (1.7)	20.7 (.8)
Pinzgauer	3	30.1 (6.2)	60.1 (5.3)	209 (4)	14.7 (1.8)	16.5 (.8)	55.4 (1.4)	5.4 (1.4)	56.8 (8.3)	124.5 (10.9)	.41 (.10)	5.5 (.7)	22.3 (.7)
Red Poll	5	20.1 (1.6)	53.6 (6.1)	191 (20)	10.0 (.5)	15.4 (.8)	50.6 (5.7)	3.1 (1.0)	56.0 (16.2)	96.4 (22.2)	.33 (.08)	5.3 (6.2)	18.4 (1.5)
Simmental	5	28.3 (1.8)	62.4 (7.3)	239 (26)	15.6 (1.9)	19.0 (2.6)	64.1 (5.8)	2.5 (.5)	37.7 (8.4)	85.7 (18.1)	.57 (.21)	6.3 (1.7)	23.5 (2.3)

[a]Values are means, with SD in parentheses.

Table 4. Prediction equation and breed estimate by breed for standard reference empty body weight

Breed	n	Prediction equation[a] b_0	b_1	Standard reference empty body weight, kg[b]
Angus	14	–.009 ± .075	.00058 ± .0001	447
Braunvieh	13	–.162 ± .039	.00071 ± .0001	584
Charolais	16	–.153 ± .074	.00059 ± .0001	679
Gelbvieh	16	–.088 ± .059	.00050 ± .0001	671
Hereford	16	–.116 ± .094	.00069 ± .0002	531
Limousin	22	–.157 ± .054	.00066 ± .0001	609
Pinzgauer	14	–.172 ± .077	.00078 ± .0001	540
Red Poll	17	–.148 ± .049	.00086 ± .0001	465
Simmental	18	–.188 ± .038	.00068 ± .0001	641

[a]$y = b_0 + b_1$ EBW when y = total empty body fat relative to empty body weight.
[b]Standard reference weight calculated as $(251 + b_0)/b_1$.

and 5.8, and mean daily dry matter feed consumption was 10.3 kg. Pooled over breed and feeding level, coefficients of variation for initial and final live weight, initial and final condition score, height, and daily feed intake were 15, 16, 24, 24, 4.6, and 21%, respectively.

Means and standard deviations by breed and feeding rate are presented in Tables 2 and 3 for weights of specific thoracic and abdominal organs and empty body constituents. Within-breed feeding rate coefficients of variation for specific organs ranged from 3 to 26% for heart, 1 to 28% for lung, 5 to 25% for the reticula-rumen complex, 6 to 32% for the small intestine, 6 to 18% for the kidney, and 10 to 28 % for liver, with the larger CV associated with two feeding rates in the Pinzgauer sample.

Standard Reference Weight Determination. Preliminary analysis suggested the relationship between proportion of empty body fat and empty body weight differed among the breeds ($P < .03$). Within-breed regressions were used to evaluate the relationship between proportion of empty body fat and empty body weight (Table 4). Standard reference empty body weights at 251 g/kg were calculated for each breed using the within-breed intercept and regression coefficient. Calculated values ranged from 447 kg for the Angus to 679 kg for the Charolais. These estimates were used to scale individual observations for empty body weight. Means and standard deviations for the ratio of individual animal digesta-blood free empty body weight at weight stasis to breed standard reference empty body weight for each breed by feeding rate subcell are presented in Table 5. Values shown are indicative of differing breed responses to dry matter feeding rates in attaining weight stasis.

Empty Body Depots. Normal adult values for proportions of the empty body as carcass, offal, and hide at 251 g/kg (fat/empty body weight) are presented in Table 6. Compared at 251 g fat/kg empty body weight, normal proportions of empty body for mature females were predicted to be 704 g/kg, 221 g/kg, and 75 g/kg for carcass, offal, and hide, respectively. For cows at weight stasis, the general relationship observed was as the proportion of empty body weight compared with standard reference weight increased, the carcass proportion became larger while

Table 5. Mean and standard deviation by breed and dry matter intake level for empty body weight at slaughter (× 100) relative to reference weight[a]

Breed	Dry matter intake level: 58 g DM/kg $wt^{.75}$	76 g DM/kg $wt^{.75}$	93 g DM/kg $wt^{.75}$	111 g DM/kg $wt^{.75}$
Angus	90.6 (5.6)	107.2 (10.0)	107.1 (-)	114.1 (2.1)
Braunvieh	68.1 (13.6)	83.4 (3.0)	107.0 (9.0)	107.7 (14.8)
Charolais	68.0 (7.8)	89.9 (6.0)	98.1 (5.9)	87.5 (2.8)
Gelbvieh	66.0 (8.9)	74.4 (13.5)	78.7 (13.2)	92.9 (9.7)
Hereford	91.8 (9.5)	91.5 (11.0)	109.9 (2.6)	108.9 (7.2)
Limousin	65.3 (10.8)	81.8 (8.2)	91.3 (6.1)	92.0 (16.9)
Pinzgauer	81.3 (10.1)	90.3 (11.6)	125.9 (-)	111.2 (4.9)
Red Poll	66.2 (5.0)	84.5 (8.3)	101.4 (9.6)	110.6 (3.9)
Simmental	65.4 (9.8)	77.1 (10.8)	110.6 (12.5)	92.8 (6.4)

[a]Reference weight is empty body weight at which fat content is 251 g/kg.

Table 6. Normal adult proportion, rates of change, and breed deviation for depots of the empty body[a]

	Carcass, g/kg	Offal, g/kg	Hide, g/kg
Normal adult (b_0)	704 ± 1.8	221 ± 1.7	75 ± .8
Rate of change (b_1)	50 ± 9.9	0	−59 ± 4.3
Breed deviation[b]	$P < .001$	$P < .001$	$P < .001$
Angus	−11.03 ± 4.8*	3.77 ± 4.6	2.19 ± 2.2
Braunvieh	−12.18 ± 4.3*	7.07 ± 4.1	2.60 ± 1.9
Charolais	23.11 ± 4.2*	−12.76 ± 4.0*	−8.59 ± 1.8*
Gelbvieh	9.25 ± 3.9*	−5.42 ± 3.8	−2.33 ± 1.7
Hereford	−5.15 ± 4.2	−8.69 ± 4.1*	8.52 ± 1.8*
Limousin	28.17 ± 3.7*	−10.12 ± 3.5*	−11.41 ± 1.6*
Pinzgauer	−21.53 ± 4.5*	6.13 ± 4.4	13.95 ± 2.0*
Red Poll	−23.72 ± 3.9*	24.09 ± 3.7*	−3.95 ± 1.7*
Simmental	13.09 ± 3.5*	−4.06 ± 4.1	−.99 ± 1.8

[a] $y = b_0 + b_1 (u - 1)$ where y = constituent/empty body weight at slaughter, u = empty body weight at slaughter/weight at 251 g fat/kg, and b_0 = estimate of normal adult proportion at u = 1.
[b] $H_0{:}b_i = 0$ breed deviation (b_i) tested with *t*-test (*$P < .05$).

the proportion in the hide depot declined. These results agree with those reported by Taylor and Murray (1991). In contrast to results reported by these researchers, the proportion of offal remained constant across feed intake levels in the present study. Taylor and Murray (1991) separated intra-abdominal fat from the offal, whereas these tissues were pooled for chemical analyses in the present study. Partitioning the offal into head and hooves (hard drop) components and visceral organs and intra-abdominal fat (soft drop) revealed a linear change in proportions associated with different proportion empty body weight per breed standard reference weight (**EBW/SRW**). With increasing EBW/SRW, the proportion of hard drop decreases (coefficient of –51.4, $P < .01$) and the proportion of the soft drop increases (coefficient of 56.1, $P < .01$). Taylor and Murray (1991) observed that for animals at weight stasis, animals sampled at smaller EBW/SRW would have a larger proportion of the empty body represented by offal tissue. Shemis et al. (1994) observed that among Danish Friesian cows managed to create differences in body condition, the proportion of all offal components, with the exception of body fat, decreased, the proportion of the carcass increased with increasing body condition, and hide proportion decreased.

With mature animals sampled at various weight stasis endpoints, a general relationship between proportion of body depots and scaled empty body weight was evident; however, breed deviations from the normal adult values were observed. When cows were evaluated at normal adult values (EBW/SRW = 1), the proportion of empty body weight in the carcasses of Angus, Braunvieh, Pinzgauer, and Red Poll cows was significantly less than estimated normal adult value whereas the proportion of empty body weight located in the carcasses for Charolais, Gelbvieh, Limousin, and Simmental exceeded normal adult proportions ($P < .05$). The deviations of Charolais (–12.8 g/kg), Hereford (–8.7 g/kg), Limousin (–10.1 g/kg), and Red Poll (24.1 g/kg) for proportion of offal differed from the standard normal proportion ($P < .05$). Considering the partitioning of offal into hard and soft drop, Angus had larger ($P < .05$) proportions and Gelbvieh smaller proportions ($P < .05$) of hard drop at all degrees of maturity. Red Poll had larger proportions of soft drop ($P < .05$) and Hereford and Charolais proportions were smaller ($P < .05$) at all degrees of maturity. Hereford and Pinzgauer had larger ($P < .05$) proportions of hide, whereas the proportion of hide for Limousin, Red Poll, and Charolais was smaller than the normal adult proportion. Pooling across feed levels, Jenkins et al. (1986) reported breed means for proportion of hide relative to slaughter weight of 70, 68, 73, 75, 69, and 71 g/kg for mature cows sired by Angus and Hereford (pooled), Red Poll, Brown Swiss, Gelbvieh, Maine Anjou, and Chianina. These results suggest that as cattle evolved a general “maturing” relationship developed for these components; however, variation in the proportion of depots relative to standard reference empty body weights was introduced as breeds were formed.

Chemical Constituents. Estimates of normal adult values, linear regression coefficients, and estimates of breed deviations for proportions of carcass water, protein, and fat are given in Table 7. These proportions are relative to empty body weight and scaled to breed standard empty body weight of 251 g of fat/kg empty body weight. Estimated normal adult value for carcass was 704 ± 1.8 g/kg. Normal adult values for chemical constituents were estimated to be 388 ± 3.1, 103 ± .7, and 174 ± 3.4 g/kg for water, protein, and fat. Ash (not presented) accounted for the remainder of the carcass depot proportion. Changes in proportion of the constituents were linear. Previously it was shown that the proportion of carcass relative to empty body weight increased as cows attained weight stasis at higher proportions of EBW at weight stasis/SRW

Table 7. Normal adult proportion, rates of change, and breed deviations for chemical constituents of the carcass[a]

	Water, g/kg	Protein, g/kg	Fat, g/kg
Normal adult (b_0)	388 ± 3.1	103 ± .7	174 ± 3.4
Rate of change (b_1)	–184 ± 17.4	–17 ± 3.7	286 ± 19.4
Breed deviation[b]	P < .04	P < .001	NS
Angus	–15.16 ± 8.4*	–5.04 ± 1.8*	
Braunvieh	–9.13 ± 7.6	–3.16 ± 1.6*	
Charolais	17.83 ± 7.3*	6.38 ± 1.6*	
Gelbvieh	2.23 ± 6.9	4.08 ± 1.5*	
Hereford	–3.15 ± 7.4	–3.63 ± 1.6*	
Limousin	18.93 ± 6.5*	6.25 ± 1.4*	
Pinzgauer	–7.81 ± 7.9	–5.65 ± 1.7*	
Red Poll	–7.55 ± 6.7	–3.72 ± 1.5*	
Simmental	4.21 ± 7.4	4.49 ± 1.6*	

[a]$y = b_0 + b_1 (u - 1)$ where y = constituent/empty body weight at slaughter, u = empty body weight at slaughter/weight at 251 g fat/kg, and b_0 = estimate of normal adult proportion at u = 1.
[b]$H_0{:}b_i = 0$ breed deviation (b_i) tested with *t*-test (*P < .05).

(regression coefficient = 50). This increase in carcass proportion is attributable to the increase in the proportion of carcass fat. As measured on animals at different weight stasis levels, a linear change in the proportions on carcass constituents occurred. As these results were derived from animals that were at weight stasis, it is not implied that during the dynamic phase between the levels a linear relationship exists. The regression coefficients for both carcass water and protein were negative. This agrees with results reported by Butterfield et al. (1983) for proportion of muscle relative to live weight. These results plus those reported by Taylor and Murray (1991) demonstrate that at higher EBW/SRW, the proportion of muscle in the carcass will be reduced. Breed differences were observed for proportions of carcass protein (P < .001) and water (P < .04). Charolais and Limousin proportion of carcass water was greater (P < .05) than the normal adult value and that of Angus was less (P < .05). In Charolais, Gelbvieh, Limousin, and Simmental breeds, protein proportion exceeded (P < .05) the normal adult value, whereas proportions in the Angus, Braunvieh, Hereford, Pinzgauer, and Red Poll were less (P < .05) than the normal adult value. The data were not able to support rejection of the hypothesis of no differences among the breeds for proportion of carcass fat relative to degree of maturity.

Estimates for proportions of chemical constituents of offal are presented in Table 8. Normal adult values for water, protein, and fat of the offal were 104, 31, and 74 g/kg, respectively. As cows attain weight equilibrium at different proportions of standardized mature weight, the proportion of empty body weight represented in the offal pool was constant (Table 5); however, the chemical composition of the offal was linearly related to the EBW/SRW. Similar to the

Table 8. Normal adult proportions, rates of change, and breed deviations for chemical constituents of offal[a]

	Water, g/kg	Protein, g/kg	Fat, g/kg
Normal adult (b_0)	104 ± 1.2	31 ± .3	74 ± 1.7
Rate of change (b_1)	–81 ± 5.5	–19 ± 1.9	121 ± 9.5
Breed deviation[b]	P < .001	P < .001	P < .001
Angus	8.64 ± 3.3*	3.45 ± .9*	–8.91 ± 4.6
Braunvieh	6.66 ± 3.0*	.35 ± .8	.44 ± 4.1
Charolais	–10.80 ± 2.9*	–2.11 ± .8*	.26 ± 3.9
Gelbvieh	–6.01 ± 2.7*	–1.79 ± .7*	2.99 ± 3.2
Hereford	3.60 ± 2.9	1.12 ± .8	–13.47 ± 4.1*
Limousin	–11.40 ± 2.6*	–1.67 ± .7	3.37 ± 3.6
Pinzgauer	3.41 ± 3.1	.05 ± .9	2.55 ± 4.3
Red Poll	8.89 ± 2.7*	1.72 ± .7*	12.44 ± 3.7*
Simmental	–3.00 ± 2.9	–1.04 ± .8	.32 ± 4.0

[a]$y = b_0 + b_1 (u - 1)$ where y = constituent/empty body weight at slaughter, u = empty body weight at slaughter/weight at 251 g fat/kg, and b_0 = estimate of normal adult proportion at u = 1.
[b]$H_0{:}b_i = 0$ breed deviation (b_i) tested with *t*-test (*P < .05.).

Table 9. Normal adult proportion, rates of change, and breed deviations for water and fat of hide[a]

	Water, g/kg	Protein, g/kg	Fat, g/kg
Normal adult (b_0)	4.6 ± .5	24 ± .3	6 ± .1
Rate of change (b_1)	−45 ± 3.0	−19 ± 1.7	9 ± 1.1
Breed deviation[b]	P < .001	P < .001	P < .001
Angus	3.13 ± 1.5*	−1.8 ± .8	1.14 ± .5*
Braunvieh	1.37 ± 1.3	1.0 ± .9	−.33 ± .5
Charolais	−5.73 ± 1.3*	1.9 ± .8*	−.89 ± .4*
Gelbvieh	−1.93 ± 1.2	−.6 ± .9	.27 ± .4
Hereford	4.48 ± 1.3*	.9 ± .7	1.93 ± .4*
Limousin	−6.78 ± 1.1*	−3.1 ± .7*	−1.12 ± .4*
Pinzgauer	8.89 ± 1.4*	−1.8 ± .8	−.30 ± .5
Red Poll	−2.26 ± 1.1	.8 ± .8	−.00 ± .4
Simmental	−1.19 ± 1.3	4.3 ± .8*	−.71 ± .4

[a]$y = b_0 + b_1 (u - 1)$ where y = constituent/empty body weight at slaughter, u = empty body weight at slaughter/weight at 251 g fat/kg, and b_0 = estimate of normal adult proportion at u = 1.
[b]$H_0{:}b_i = 0$ breed deviation (b_i) tested with *t*-test (*P < .05).

carcass fractions, as cows attained weight equilibrium at weights at larger proportions of the standardized weight, the proportions of water and protein in the offal decreased and the proportion of fat increased. Significant deviations from normal adult values attributable to breed were observed. Angus, Braunvieh, and Red Poll had a higher proportion of water at all weight stasis levels, and Charolais, Gelbvieh, and Limousin had smaller proportions (P < .05). Angus and Red Poll proportions of protein exceeded normal adult value (P < .05), whereas the proportions of protein for Charolais and Gelbvieh were less (P < .05). Compared with normal adult value for proportion of offal fat, Hereford had a smaller proportion and Red Poll a larger proportion at all weight stasis levels (P < .05).

Normal adult proportions, rates of change in proportions, and breed deviations for water, protein, and fat constituents of the hide are presented in Table 9. The normal adult proportion for hide is 75 g/kg when empty body weight at weight stasis is equal to the standard reference empty body weight. Shemeis et al. (1994) reported a range 6.2 to 6.7% for hide relative to slaughter weight in mature cows in various levels of body condition. Approximately 46 g/kg EBW is water, 24 g/kg EBW is protein, and 6 g/kg EBW is fat. As cows attain weight stasis at smaller than standard reference weight, the proportion of water in the hide increases while the proportion of fat decreases. The proportion of water in hide of Angus, Hereford, and Pinzgauer exceeded the normal adult proportion, whereas the estimated proportions of Charolais and Limousin were smaller (P < .05). With increasing proportions of standard reference weight, the protein proportion decreased. At all weight stasis endpoints, estimated hide protein of the Simmental was greater and the hide protein proportion of the Limousin smaller (P < .05). A positive relationship between hide fat proportion and proportion of empty body weight at weight stasis and standard reference weight was observed similar to the relationships for carcass and offal components. Hereford and Angus proportions of hide fat were greater than the normal adult value, and Limousin and Charolais were smaller (P < .05).

Specific Organs. Estimates of normal adult proportions, relationships with various EBW/SRW, and breed deviations are reported in Table 10. Normal adult values were 29.5, 11.5, 11.1, 5.6, 4.9, and 2.5 g/kg for the rumen complex, small intestine, liver, lung, heart, and kidney. These proportions are in the range of breed means reported by Jenkins et al. (1986) for mature cows representing diverse cattle breeds when pooled over various feed rates of feed intake. In that study, cows of all breeds receiving higher daily rations had smaller proportions of lung, heart, and kidney but larger proportions of liver and empty gastrointestinal tract (sum of rumen complex, small and large intestines). The cattle in the study reported by Jenkins et al. (1986) had not attained weight stasis at time of slaughter, and proportions were not relative to EBW/SRW. In the present study, the proportions of all organs decreased with increasing EBW/SRW. With the exception of the liver, these results agree with Taylor and Murray (1991). These authors reported no relationship for proportion of liver and EBW/SRW for mature cows representing breeds differing in mature size and milk production potential. Significant breed differences from normal adult values were observed for all organs. The proportions of heart, lung, rumen complex, small intestine, and liver for Limousin were less (P < .05) than normal adult values. Charolais and Gelbvieh proportions of lung and small intestine were smaller than normal adult proportions (P < .05). The deviations from normal adult values for proportion of liver of the Charolais and Hereford were negative (P < .05). Simmental proportions of lung and kidney were smaller than the normal adult values (P < .05). The proportions exhibited by Red Poll for all

Table 10. Normal adult proportions, rates of change, and breed deviations for specific visceral organs[a]

	Heart, g/kg	Lung, g/kg	Rumen, g/kg	Small intestine, g/kg	Liver, g/kg	Kidney, g/kg
Normal adult (b_0)	4.9 ± .1	5.6 ± .1	29.5 ± .5	11.5 ± .1	11.1 ± .1	2.5 ± .1
Rate of change (b_1)	−2.6 ± .4	−6.5 ± .8	−32.7 ± 2.8	−4.3 ± 1.0	−3.7 ± .6	−2.2 ± .4
Breed deviation[b]	P < .03	P < .001	P < .001	P < .001	P < .001	P < .01
Angus	.44 ± .2	.96 ± .3*	5.68 ± 1.4*	0.9 ± .5	.51 ± .3	.29 ± .2
Braunvieh	.36 ± .2	.27 ± .3	.03 ± 1.1	1.34 ± .5*	.72 ± .3*	.10 ± .2
Charolais	−.26 ± .2	−.86 ± .3*	−2.25 ± 1.2	−1.22 ± .4*	−.76 ± .3*	−.22 ± .2
Gelbvieh	−1.5 ± .2	−.19 ± .3	−3.82 ± 1.1*	−1.74 ± .4*	−.30 ± .3	−.38 ± .1*
Hereford	.12 ± .2	.25 ± .3	1.35 ± 1.2	.79 ± .5	−.98 ± .3*	.05 ± .2
Limousin	−.44 ± .2*	−1.15 ± .2*	−3.82 ± 1.1*	−1.05 ± .4*	−1.19 ± .2*	.00 ± .1
Pinzgauer	−.30 ± .2	.16 ± .3	1.40 ± 1.3	−.01 ± .5	.52 ± .3	.02 ± .2
Red Poll	.18 ± .2	.95 ± .3*	3.22 ± 1.1*	1.35 ± .4*	1.56 ± .2*	.46 ± .1*
Simmental	.08 ± .2	−.40 ± .3	−1.73 ± 1.2	.44 ± .5	−.07 ± .3	−.32 ± .1*

[a]$y = b_0 + b_1 (u - 1)$ where y = constituent/empty body weight at slaughter, u = empty body weight at slaughter/weight at 251 g fat/kg, and b_0 = estimate of normal adult proportion at u = 1.
[b]$H_0: b_i = 0$ breed deviation (b_i) tested with t-test (*P < .05).

organs, with the exception of lung, were greater than normal adult values (P < .05). Angus had greater proportions of lung and rumen complex and Braunvieh had greater proportion of intestine and liver (P < .05).

Implications

Feeding standards provide descriptions of nutrient needs for cow-calf producers. Energy expenditure for maintenance in the cow herd needs to be accurately predicted. Breeds of cattle vary in maintenance requirements. Part of the differences may be attributable to variation in proportions of body components. Mature cows of different breeds attain weight stasis at different fractions of a breed standard reference weight. Relative to standard reference weight, variation exists among breeds for proportions of chemical composition of the carcass, offal, and hide. This variation may contribute to breed differences in maintenance requirement that affect production efficiency of the cow herd.

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